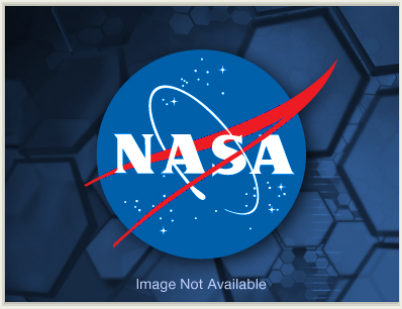
Nancy Grace Roman Technology Fellowship

UV LED-based Charge Management System for the LISA Gravitational Reference Sensor

Completed Technology Project (2016 - 2020)

Project Introduction

Within the next ~year, we will see the advent of observational gravitational wave astronomy. The twin Advanced Laser Interferometer Gravitational-wave Observatories (LIGO) have just concluded their first observation run, with sensitivities meeting the LIGO lab's highest expectations in the 10 Hz to 1 kHz frequency band. Pulsar timing arrays, which observe gravitational waves in the nHz range, will soon follow LIGO gravitational wave detections. However, it is gravitational wave observation in the 0.1 mHz to 1 Hz band, which can only be observed from space, that provides the richest and most compelling science. A space-based observatory will improve our understanding of the formation and growth of massive black holes, create a census of compact binary systems in the Milky Way, test general relativity in extreme conditions, and enable searches for new physics. All space-based gravitational wave observatories, like the Laser Interferometer Space Antenna (LISA), require free falling masses where all classical external forces are reduced below the tidal forces of the oscillating spacetime metric. A single test mass together with its protective electrode housing and associated components is referred to as a gravitational reference sensor (GRS). The journey toward a space-based observatory is well underway with the successful December 2015 launch of LISA Pathfinder (LPF), which is now stationed at its Earth-Sun L1 operating point. LPF will test the GRS and its closed loop drag-free operation. However, the design of the LPF gravitational reference sensor was solidified more than a decade ago. Since that time, new component technologies have been developed that can improve the sensor's acceleration noise performance and/or reduce complexity and technological risk. An advanced charged management system (CMS) is one such technology that has become one of the highest technological needs for a future space-based observatory, according to the Gravitational Observatory Advisory Team's interim report. This assessment is based on the marginal performance of the existing LISA Pathfinder CMS both in laboratory experiments and in testing of the LPF flight hardware. The charge management system controls the bulk potential of the test mass relative to its housing, which is vital for reducing force noise acting on the test mass below the required level. We will develop an advanced charge management system to technology readiness level (TRL) 5 by 2020 that will utilize new, efficient, semiconductor UV sources instead of the Hg vapor lamps used by LISA Pathfinder. Compared to Hg lamps, these UV LEDs are smaller and lighter, consume less power, have a wider spectrum selection, and a much higher dynamic range, with at least an order of magnitude improvement in each performance area. The proposed CMS will improve the robustness of test mass charge control by taking advantage of the higher energy (lower wavelength) UV light produced by these sources, as well as the higher-bandwidth that enables AC charge control, a scheme that is more impervious to test mass or electrode housing surface impurities. Preparations for NASA's contribution to the European Space Agency (ESA)-led L3 gravitational wave mission have begun. Although the launch of this observatory is planned for the early 2030's, any potential NASA technology contribution must reach TRL 5 by the year



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Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Responsible Program:

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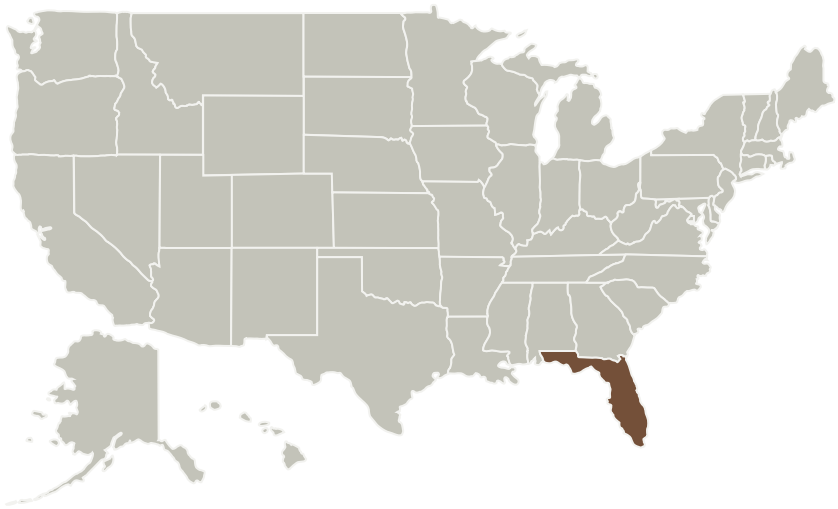
2020, according to the ESA schedule. Therefore, gravitational wave technology development in the U.S. is an immediate priority for NASA. The CMS technology proposed here has already been identified as a potential NASA contribution to the L3 mission by the European eLISA Consortium and by NASA itself. Since the L3 mission plans to switch to a UV LED-based CMS, and because of the PI's expertise with this important GRS technology and the fact that UV LEDs are only produced by vendors in the U.S., the proposed technology is a natural NASA contribution to the L3 mission.

Primary U.S. Work Locations and Key Partners



Primary U.S. Work Locations
Florida

Project Management

Program Director:

Mario R Perez

Program Manager:

Mario R Perez

Principal Investigator:

John W Conklin

Co-Investigators:

Brian Prindle
Guido Mueller

Technology Areas

Primary:

- TX08 Sensors and Instruments
  - TX08.1 Remote Sensing Instruments/Sensors
    - TX08.1.1 Detectors and Focal Planes

Target Destination

Outside the Solar System